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guides to maintain the semiconductor wafers in a vertical orientation during wafer processing at elevated temperatures;

- c) a lower grooved portion upon which a portion of the wafer is in contact, and which supports the weight of the wafer when the wafer is positioned thereon, the grooved portion having an arcuate configuration which, at semiconductor processing temperatures of between approximately 1000 °C to 1400 °C, substantially conforms to the portion of the wafer supported thereon; and
- d) at least one window positioned not more than 10 mm from the first and second ends of the boat.

13. (Amended) The wafer boat of claim 12, wherein the silicon carbide is recrystallized silicon carbide.

### REMARKS

Upon entry of the present amendment, Claims 1-13 are pending in this application. The present amendment does not introduce new matter.

Claims 1-13 have been rejected.

Claims 1, 3, 5, 7, 9-11 and 13 have been amended.

Attached hereto is a marked-up version of the changes made to the claims by the current amendment. The attached page is captioned "VERSION WITH MARKINGS TO SHOW CHANGES MADE".

The Examiner's rejections and objections will be addressed in turn as set forth in the Office Action.

## **THE INVENTION**

The applicant's invention is directed broadly to a horizontal, silicon carbide semiconductor wafer boat configured to reduce wafer slip and wafer mechanical stress. The wafer boat of the present invention is configured to reduce the likelihood of wafer slip when wafers are heated to processing temperatures in excess of about 1000 °C. The inventive wafer boat includes two upper support guides to maintain the wafer in the vertical orientation, and a lower, supporting groove to support the weight of the wafer. The material of the boat is selected, and the lower, supporting groove is shaped, such that when the wafer and boat are subjected to wafer processing temperatures of about 1000 °C and above, the shape of the lower, supporting groove will substantially correspond to the shape of the wafer contacting the groove, thereby supporting the wafer across the entire arc over which the wafer is contacted by the groove.

### **I. DRAWINGS**

Formal drawings were submitted to the Official Draftsman on June 12, 2001.

### **II. CLAIM OBJECTIONS**

Claims 1 and 9-11 are objected to because the second occurrence of the term "comprising" should be --comprises--. Further, the Office Action recites that in claims 9-11, the phrase "one or more windows" should be changed to --at least one window--. With regard to claims 1 and 11, the Applicant thanks the Examiner for his suggestions to overcome these objections. With regard to claims 9 and 10, there is no second occurrence of the term "comprising" in these claims. The objection on this ground should thus be withdrawn. With regard to the phrase "one or more

windows” in claims 9-11, these claims have been amended in accordance with the Examiner’s suggestions and thus the objection on this ground should be withdrawn.

### **III. REJECTION UNDER 35 U.S.C §112, SECOND PARAGRAPH**

Claims 1-13 have been rejected under 35 U.S.C §112, second paragraph, as being indefinite for failing to particularly point out and distinctly claim the subject matter which the applicant regards as the invention.

With respect to claim 1, the Office Action recites that the claim is unclear whether the combination or the subcombination is being claimed because the preamble implies subcombination while the body of the claim positively requires the combination. With all due respect to the Examiner, lines 5-7 of claim 1 does not positively require the combination. Nevertheless, to more clearly recite what applicant regards as its invention, claim 1 has been amended. In its amended form, the rejection to claim 1 under 35 U.S.C §112, second paragraph is thus moot and the rejection thereto should be withdrawn.

With respect to claim 3, the Office Action recites that it is unclear as to what Applicant intended to set forth when reciting “recrystallized silicon carbide”. Claim 3 is a dependent claim which depends directly from claim 2 and indirectly from claim 1 and thus incorporates all the limitations of these claims therein. Claim 3, further defines claim 2, and has been amended to recite that the silicon carbide from which the boat is fabricated, is recrystallized silicon carbide. Support for this claim can be found in the specification on Page 3, lines 13-22 , Page 11, lines 19-25 and Page 12, lines 3-16. Accordingly, the rejection to claim 3 under 35 U.S.C §112, second paragraph is thus moot and the rejection thereto should be withdrawn.

With respect to claim 5, the Office Action recites that the claim appears to be presented improperly in an independent form. The Office Action further recites that it is unclear to which structures on the boat define an angle. Claim 5 is a dependent claim that depends directly from claim 1. Without conceding that claim 5 is not in proper dependent form, claim 5 has been amended to overcome the Examiner's concern that claim 5 is presented improperly in an independent form. As such, the rejection to claim 5 under 35 U.S.C §112, second paragraph is thus moot and the rejection thereto should be withdrawn.

With respect to claim 7, the Office Action recites that the positive recitation of semiconductor wafers renders the claim indefinite because it is unclear whether a combination or subcombination is being claimed. The Office Action notes that the preamble of claim 1 implies that only the subcombination is being claimed. Applicant disagrees with the Examiner's contention that claim 7 is indefinite because it is unclear whether a combination or subcombination is being claimed. Nevertheless, claim 7 has been amended to more particularly point out and distinctly claim what applicant regards to claim as its invention.

With respect to claim 9, the Office Action recites that the claim is incomplete for omitting the necessary structural cooperative relationship with the structure thereon the boat. The Office Action notes that no structural connection or relationship is set forth between the claimed elements. Applicant respectfully disagrees with the Examiner and traverses this rejection. Claim 9 is a dependent claim which depends directly from claim 1 and thus incorporates all the limitation of claim 1 therein. As amended, claim 9 recites the boat of claim 1 further comprising at least one window positioned not more than 10mm from the first and second ends of the boat. Applicant does not believe any further structural cooperative relationship is required by this dependent claim.

Pursuant to 37 C.F.R §75(c), "[o]ne or more claims may be presented in dependent form, referring

back to and to further limiting another claim or claims in the same application" (emphasis added).

This is all that is required of a proper dependent claim. Claim 9 is a proper dependent claim since refers back to claim 1 and further limits the wafer boat of claim 1. As such, Applicant respectfully requests that the rejection of claim 9 be withdrawn.

Claim 11 has been rejected for the same reasons recited with regard to claims 1 and 9 above. As recited in response to the rejection to claim 1, with all due respect to the Examiner, claim 11 does not positively require the combination. For the same reasons stated with regard to claim 9, applicant respectfully disagrees with the Examiner's contention that the rejection to claim 9 is applicable to claim 11. Nevertheless, to more clearly recite what applicant intends as its invention, claim 11 has been amended. In its amended form, the rejection to claim 11 under 35 U.S.C §112, second paragraph is thus moot and the rejection thereto should be withdrawn.

#### **IV. REJECTION UNDER 35 U.S.C §102**

Claims 1, 2, 11 and 12 have been rejected under 35 U.S.C. §102(b) as being anticipated by U.S. Pat. No. 5,538,230 to Sibley (hereafter referred to as "Sibley").

The Action recites that Sibley discloses a silicon carbide wafer boat comprising a plurality of slots that position between first and second ends, each of the slots comprises the upper support guides that maintain the semiconductor wafer in a vertical position, an arcuate lower grooved portions that support the weight of the wafer when the wafer is positioned thereon, and at least one window spaces apart between first and second ends on the wafer boat. The Office Action notes that the strip between slots (35) is considered to be the support guides.

Anticipation requires the presence, in a single prior art reference, disclosure of each and every element of the claimed invention, arranged as in the claim. (Richardson v. Suzuki Motor Co., 8 USPQ2d 1913, 1920 (Fed. Cir. 1989)).

Sibley does not disclose each and every element of amended claim 1, arranged as in the claim. Sibley is directed to a wafer carrier comprised of a single piece of silicon carbide configured as a cylindrical shell section (22) and which has an outer convex surface (23) and an inner concave surface (24). The cylindrical shell (22) lies outside the radius of inner concave surface (24). The boat (20) disclosed in Sibley has four slot-containing inwardly convex surfaces (34) which extend toward the wafer center to a distance  $r_3$ . Surfaces (34) are provided with a plurality of grooves or slots (35) into which the wafers are placed. This embodiment is illustrated in Fig. 1 of Sibley. In an alternative embodiment disclosed in Sibley, and illustrated in Fig. 3, the boat is provided with only two inwardly extending surfaces (34), each of which has a row of slots (35) equally spaced along the longitudinal axis of the cylindrical shell.

↓ The present invention discloses the embodiments of Sibley in the Background section and illustrates the first Sibley embodiment in Fig. 1 of the present application. The present application on page 7, line 12 to page 10, line 19 discusses the Sibley-type wafer boat and the inherent disadvantages of this design, namely the problem of mechanical stress inflicted upon the wafers, which may stem from the configuration of the Sibley-type wafer boat and the slots therein.

The wafer boat of amended claim 1 of the present application recites the novel feature of a lower grooved portion (element 20 in the figures) upon which a wafer, positioned in the slots of the boat, is in contact with, and which supports the weight of the wafer. The lower grooved portion is of arcuate configuration, which at processing temperatures of between approximately 1000 °C to 1400 °C, substantially conforms to the portion of the wafer supported thereon. The wafer boat

having this configuration provides exceptional support for and stabilization of wafers positioned in the slots of the boat. (Specification, Page 11, lines 14-15).

Accordingly, Sibley does not disclose each and every element of amended claim 1 of the present invention, arranged as in the claim. In view of the above, claim 1 of the present application is patentably distinguishable over Sibley and is not anticipated. Claim 2 depends directly from claim 1 and incorporates all the limitations of claim 1 therein. As such, claim 2 is not anticipated by Sibley for at least the same reasons as those with regard to claim 1.

Amended claim 11 is similar to amended claim 1 with the exception that amended claim 11 further includes at least one window positioned not more than 10 mm from the first and second ends of the boat. For the same reason as discussed with regard to amended claim 1, Applicant submits that amended claim 11 is not anticipated by Sibley since Sibley does not disclose each and every element of amended claim 11, arranged as in the claim. Claim 12 depends directly from claim 1 and incorporates all the limitations of claim 1 therein. As such, claim 12 is not anticipated Sibley for at least the same reasons as those with regard to claim 11.

Accordingly, applicant submits that rejected claims 1, 2, 11 and 12, and all claims which depend therefrom, are allowable and should be advanced to allowance. Reconsideration and withdrawal of the rejection on these grounds is respectfully solicited.

**V. REJECTION UNDER 35 U.S.C §103**

Claims 3-10 and 13 stand rejected under 35 U.S.C §103(a) as being unpatentable over Sibley as applied to claims 1, 2, 11 and 12 in the rejection under 35 U.S.C §102, and further in view of obviousness in one of ordinary skill in the art.

With respect to claims 3 and 13, the Office Action recites that to one of ordinary skill in the art it would have been obvious that the silicon carbide would recrystallize itself to a normal state after exposed to the high temperature when placed in a cooler environment. The Office Action further states that with respect to the dimensioning of the wafer, the angle dimensioning on the wafer boat, the thickness of the wafer boat, and the distance between the windows on the wafer boat, it would have been an obvious matter of engineering design choice as determined through routine experimentation and optimization for one of ordinary skill in the art to routinely dimension the diameter of the wafer to be about 300mm and dimension the angle thereon the wafer boat to be ranging from 10-80 degrees, the thickness of the wafer boat to be about 5mm and the distance between windows to be 10mm for a particular application, thus producing no unexpected results.

With respect to claim 7, the Office Action recites that it would have been obvious to one of ordinary skill in the art as a matter of design choice to make duplication in part of the number of slots thereon the wafer boat in order to accompany the desired number of semiconductor wafers for a particular application thus producing no new matter.

As recited above with respect to the rejection under 35 U.S.C. §102(a), the present application claims a semiconductor wafer boat which is significantly different from that disclosed by Sibley and which overcomes the disadvantages of the Sibley boat. In this regard, Sibley teaches away from the boat of the present invention and is not even a proper reference under 35 U.S.C. §103(a). Claims 3-10 depend directly or indirectly from amended claim 1 and incorporate all the limitations of amended claim 1 therein. Claim 13 depends directly from claim 12 and indirectly from claim amended claim 11 and incorporates all the limitations of those claims therein.

Obviousness requires that there be some motivation, suggestion, or teaching of the desirability of making the specific combination that was made by the applicant. (In re Kotzab, 55



USPQ2d 1313, 1317 (Fed. Cir. 2000)). Independent claims 1 and 11 are not obvious in light of Sibley since Sibley does not teach or suggest a wafer boat having a lower grooved portion upon which a wafer, positioned in the slots of the boat, is in contact, and which supports the weight of the wafer. The grooved portion being of arcuate configuration, which at processing temperatures of between approximately 1000 °C to 1400 °C, substantially conforms to the portion of the wafer supported thereon. Since claims 3-10 depend directly or indirectly from amended independent claim 1, these claims incorporate all the limitations of claim 1 and the intervening claims. As such, claims 3-10 are not obvious in view of Sibley. Additionally, claim 13 depends indirectly from amended independent claim 11 and incorporates the limitations of claim 11 therein. Thus, claim 13 is not obvious in view of Sibley

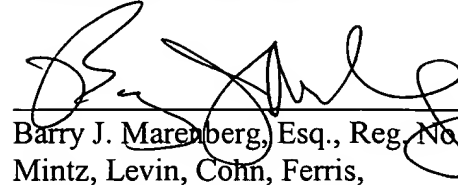
In view of the above, claims 3-10 and 13 are not unpatentable under 35 U.S.C. §103(a) over Sibley as applied to claims 1, 2, 11, and 12 as set forth in the rejection under 25 USC §102(b), and further in view of obviousness in one of ordinary skill in the art.

## **VI. CONCLUSION**

Applicant has made a significant contribution to the art, neither disclosed nor suggested in any cited reference. It is submitted that all claims are in condition for immediate allowance, which action is respectfully solicited.

**If, upon receipt and review of this amendment, the Examiner believes that the present application is not in condition for allowance and that changes can be suggested which would place the claims in allowable form, the Examiner is respectfully requested to call Applicant's undersigned counsel at the number provided below.**

Respectfully submitted,

A handwritten signature in black ink, appearing to read "Barry J. Marenberg", is written over a horizontal line.

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Dated: August 31, 2001

**VERSION WITH MARKINGS TO SHOW CHANGES MADE**

**In the specification:**

Paragraph beginning at line 18 on page 10 and extending to line 18 on page 11 has been amended as follows:

Taking the several considerations outlined above into account, the inventive wafer boat was developed. FIGS. 2 and 3 are schematic representations of one embodiment of the wafer boat 10 in accordance with the present invention, as viewed from different angles. In particular, unlike current wafer boats which provide support for each wafer at four points (two lower points to support the weight of the wafer, and two upper points to maintain the wafer in the vertical orientation as illustrated in FIG. 1), the wafer boat of the present invention is provided with two upper support guides 18a, 18b to maintain the wafer 12 in the vertical orientation, and a single lower supporting grooved portion 20 to support the weight of the wafer 12. Once the material of which wafer boat 10 is fabricated is selected, the supporting grooved portion 20 which is in a plane lower than the upper support guides 18a, 18b, is shaped having an arcuate configuration such that, when the wafer 12 and wafer boat 10 are subjected to wafer processing temperatures of about 1000 °C and above, the shape of the supporting grooved portion 20 will substantially correspond to the shape of the part of the wafer 12 contacting the supporting grooved portion 20, thereby supporting the wafer 12 across the entire arcuate portion of a circular wafer's periphery which is in contact with the supporting grooved portion. In other words, the lower arcuate periphery of the circular wafer rests upon and is supported by the supporting grooved portion 20 when the wafer 12 is positioned in a slot 14 in wafer boat 10 and maintained in a vertical position by the upper support guides 18a, 18b. The wafer boat 10 having this configuration provides exceptional support for and stabilization of the [waters] wafers 12 positioned in the slots 14. Additionally, the wafer boat 10 of the present invention includes one or more large openings or windows 22 between each end of the boat in order to

increase the radiation view factors and decrease radiation blocking caused by the boat, as compared to boats currently known in the art.

Paragraph beginning at line 5 on page 13 has been amended as follows:

In the case of a wafer boat for use with a 300 mm wafer, in one embodiment, the boat includes 10 slots intended to hold 10 wafers. Such a boat is approximately 11 cm long. The opposing upper supports are positioned approximately 6.8 cm above the lowest point of the groove, and spaced apart from one another by approximately 10.4 cm. Each slot will have a width of approximately 0.89 mm. The groove will have an arc length of approximately 20.82 mm. FIG. 4 depicts a triangle having a hypotenuse "A" defined as the wafer radius extending from the center of the wafer to the wafer periphery or edge at a point at which one of the upper support guides holds the wafer in the slot [,. [an] An angle  $\alpha$  defined between the hypotenuse "A" and a radius "B" originating at the center of the wafer and extending downward to a point on the wafer periphery which is positioned in the middle of the grooved portion on which the wafer rests. A third radius "C" extends from the center of the wafer to the periphery of the wafer to a point at which the second upper supporting guide holds the wafer in the slot. In the inventive wafer boat, the angle  $\alpha$  is in the range of 10 degrees to 80 degrees, and optimally about 37 degrees. The total angle defined between radius A and radius C is approximately 74 degrees.

**In the claims:**

Claims 1, 3, 5, 7, 9-11 and 13 have been amended as follows:

1. (Amended) A semiconductor wafer boat [for holding a semiconductor wafer during wafer processing at elevated temperatures, the wafer boat having first and second ends and] comprising:

a) first and a second end;

[a)] b) a plurality of slots positioned between the first and second ends for receiving

semiconductor wafers therein, each of the slots [comprising] comprises first and

second upper support guides to maintain the semiconductor wafers in a vertical orientation during wafer processing at elevated temperatures; and

[b)] c) a lower grooved portion upon which a portion of the wafer is in contact, and which supports the weight of the wafer when the wafer is positioned thereon, the grooved portion having an arcuate configuration which, at semiconductor processing temperatures of between approximately 1000 °C to 1400 °C, substantially conforms to the portion of the wafer supported thereon.

3. (Amended) The wafer boat of claim 2, wherein the silicon carbide [comprises] is recrystallized silicon carbide.
5. (Amended) The wafer boat of claim 1, [defining] wherein an angle  $\alpha$  in the range of 10-80 degrees is defined between a first radius of the wafer extending from the center of the wafer to the periphery of the wafer proximate the first upper support guides and a second radius extending vertically downward from the center of the wafer to a point on the periphery of the wafer which corresponds to the center of the grooved portion, [and wherein the angle  $\alpha$  is in the range of 10 - 80 degrees].
7. (Amended) The wafer boat of claim 1, wherein the [boat comprises] plurality of slots [to] between the first and second ends of said boat are configured to support up to 25 semiconductor wafers .
9. (Amended) The wafer boat of claim 1, further comprising [one or more windows] at least one window positioned not more than 10 mm from the first and second ends of the boat.

10. (Amended) The wafer boat of claim 9, wherein the [one or more windows] at least one window [increase] increases radiation distribution about the wafers in the boat when the boat undergoes processing at elevated temperatures.
11. (Amended) A semiconductor wafer boat [for holding a semiconductor wafer during wafer processing at elevated temperatures, the wafer boat having first and second ends and] comprising:
- a) first and second ends;
  - [a)] b) a plurality of slots positioned between the first and second ends for receiving semiconductor wafers therein, each of the slots [comprising] comprises first and second upper support guides to maintain the semiconductor wafers in a vertical orientation during wafer processing at elevated temperatures; [and]
  - [b)] c) a lower grooved portion upon which a portion of the wafer is in contact, and which supports the weight of the wafer when the wafer is positioned thereon, the grooved portion having an arcuate configuration which, at semiconductor processing temperatures of between approximately 1000 °C to 1400 °C, substantially conforms to the portion of the wafer supported thereon; and
  - [c)] d) [one or more windows] at least one window positioned not more than 10 mm from the first and second ends of the boat.
13. (Amended) The wafer boat of claim 12, wherein the silicon carbide [comprises] is recrystallized silicon carbide.